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# Damage to Guayule by Insects and Mites With Notes on Control

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## INTRODUCTION

The guayule shrub (*Parthenium argentatum* A. Gray) is native to north-central Mexico and adjacent areas in the Big Bend section of Texas. Several varieties of the species have been developed by plant breeders, but variety No. 593 has been cultivated, principally for commercial rubber production. The plant deposits some rubber each year, chiefly in the cells in the cortex of trunk, branches, and roots. It may live for 30 years or longer, but under cultivation it apparently reaches its peak of production in 4 to 6 years. Under optimum growing condi-

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tions the plant will accumulate 1,200 to 1,800 pounds of crude rubber per acre during this period.

In the spring of 1942 three large nurseries covering 530 acres were seeded for large-scale plant production in the Salinas Valley, Calif. Seedlings that already had been grown under nursery conditions were transplanted that spring to 900 acres also in the Salinas Valley. In 1943 and 1944, however, more than 31,000 acres were transplanted for rubber production on land leased in California. Experimental plantings were made in Arizona, New Mexico, and Texas.

The Forest Service, in carrying out its guayule program under the Emergency Rubber Project in 1942, was confronted by insect-control problems. It asked the Bureau of Entomology and Plant Quarantine to assist in their solution. In 1943 and 1944 a number of important insect problems developed, and satisfactory control measures were devised.

This circular deals with the insects and mites found while guayule was being grown in nurseries, field plantings, and greenhouses in California, Arizona, New Mexico, and Texas, from 1943 to 1945. The various insects will be discussed in the order used by Essig (*2*),[5] not in the order of their importance.

Lloyd (*4*) reported on pests of wild guayule found while studying the plant in Mexico from 1907 to 1909. He recorded a guayule bark beetle, *Pityophthorus nigricans* Bland., which attacked wood where growth had stopped; a gallfly, the larvae of which distorted the leaves and inflorescence, causing small galls; and two scale insects, *Orthezia* sp. and *Rhizaspidiotus dearnessi* (Ckll.), and a mealybug, *Puto yuccae* (Coq.), which attacked the roots. Romney (*5*) reported on insects attacking guayule in northern Mexico. Baumhofer (*1*) discussed the potential pests of guayule and those already known to attack it. Lange (*3*) discussed certain insects and control measures used while working on the problem during the late summer of 1942.

## NURSERY INSECTS

Guayule plants are grown first in nurseries. The plants shown in figure 1 are large enough to be topped, dug, crated, and made ready for transplanting under field conditions. Several kinds of insects developed on guayule plants growing under nursery conditions.

### Thrips

Thrips reproduced in large numbers on small guayule plants. Their feeding caused the leaves to curl and become distorted (fig. 2). Experiments have shown that by the end of the first growing season the plants sprayed for control of thrips appear no different than the untreated checks, even though good control is effected. The unsightly appearance of the plants during June and July seemed the most objectionable feature. Thrips collected from distorted plants in a nursery near Salinas, Calif., on July 5, 1943, showed *Frankliniella occidentalis trehernei* Morg. and the onion thrips (*Thrips tabaci* Lind.) to be about equally abundant and to constitute the major part of the infestation. Some *Chirothrips aculeatus* Bagn. and a few *F. occidentalis* (Perg.) were also in the collection. From a collection made in the same nursery the preceding season Lange (*3*) reported that *F.*

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[5] Numbers in parentheses refer to Literature Cited, p. 19.

*Figure 1.*—A guayule nursery showing plants that have completed growth for the season. (Photograph by W. A. Campbell, Bureau of Plant Industry, Soils, and Agricultural Engineering.)

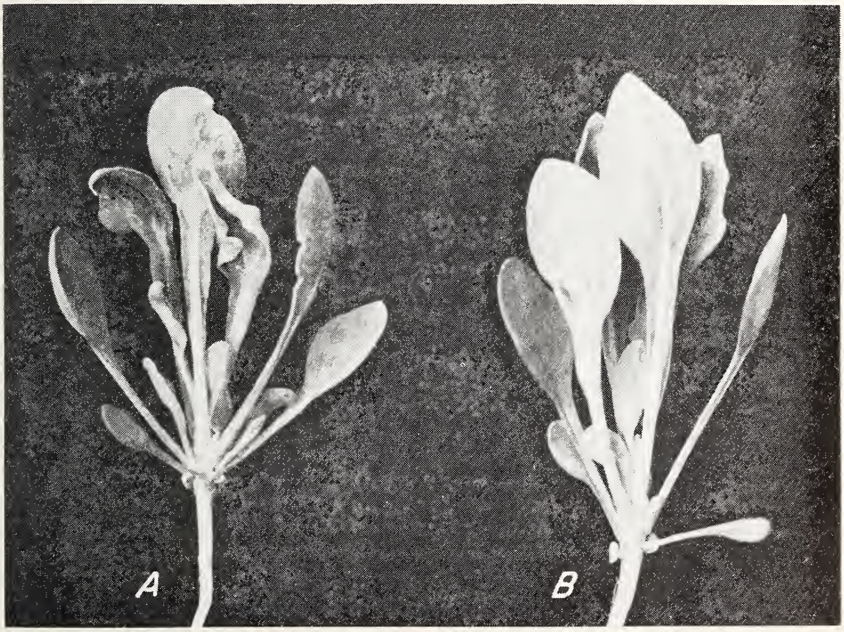

*Figure 2.*—Small guayule plant with leaves distorted and curled from thrips injury (*A*), compared with a normal plant (*B*).

*moultoni* Hood (= *occidentalis* (Perg.)) and *F. minuta* Moulton were the most common species.

During the 1943 season, thrips in the Alisal nursery near Salinas were effectively controlled by two applications, 1 week apart, of a spray containing 4 pounds of tartar emetic and 16 pounds of sugar per 100 gallons of water. The spray was applied with a power sprayer at the rate of 23.6 gallons per acre. After 3½ days 70 percent of the thrips had been killed. In 1944 a 0.3-percent DDT emulsion, applied with a paint gun at an air pressure of 80 to 90 pounds per square inch, gave effective control of thrips within 48 hours.

***Caution.*—Tartar emetic, DDT, paris green, calcium arsenate, and cryolite are poisonous to animals and man. Use these spray materials according to instructions, and do not allow children and livestock to have access to them.**

## APHIDS

Aphids occasionally became abundant in guayule nurseries in California. Control was not necessary, however, as parasites and predators reduced their numbers before noticeable damage was done. The green peach aphid (*Myzus persicae* (Sulz.)), the melon aphid (*Aphis gossypii* Glov.), and *Anuraphis helichrysi* (Kalt.) reproduced on young guayule plants.

## BEETLES

A darkling ground beetle, *Ulus crassus* (Lec.), injured cotyledon stage guayule in the Mission nursery at Oceanside, Calif., in April 1943. The beetles fed on the terminals, thereby killing many plants outright and injuring others. Random counts showed the number of plants killed by beetles ranged from 0 to 19 and averaged 4 per square foot.

Preliminary control tests were made with a poison bait mixed at the rate of 4 pounds of paris green to 100 pounds of sweetened bran, plus enough water to make the material moist and flaky. The bait was applied by hand at rates of 2, 3, and 5 pounds per bed (4 by 400 feet). The beetles fed readily on it, and the 2-pound dosage gave as good control as the higher dosages. Bait in the usual quantity—1½ pounds per bed or about 40½ pounds per acre—was applied to the rest of the nursery April 13–23. A total of 3,507 beds, or about 130 acres, were treated. Random counts made from 36 to 48 hours after baiting showed effective control.

The western spotted cucumber beetle (*Diabrotica undecimpunctata* Mann.) was injurious to guayule, principally in the cotyledon stage, and reduced stands in the nurseries and in a field near Salinas. Control measures were not required on the older plants, although occasional infestations were found wherein the beetles had eaten many holes in the leaves. The insects remained in the guayule only about 10 days, however. Dusting plants in the cotyledon stage with either straight calcium arsenate or 50-percent cryolite gave satisfactory protection to the stands under nursery conditions. The insect was highly susceptible to DDT dusts in cage tests, but no field tests were made.

## WIREWORMS

Wireworms attacked the roots of small guayule plants in some nurseries (fig. 3), damage being proportional to the numbers of worms

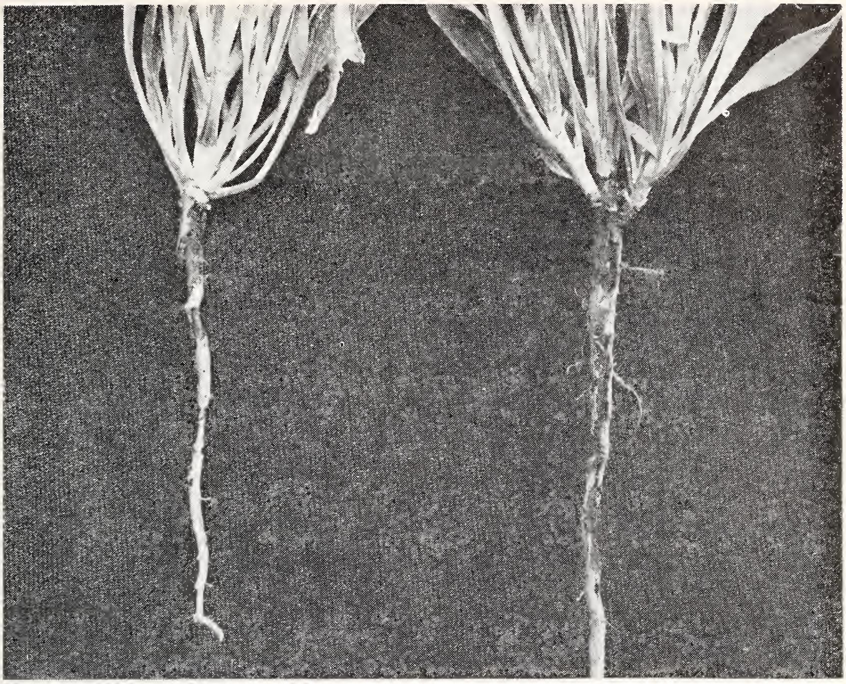

*Figure 3.*—Wireworm damage to guayule nursery stock. Removal of cortex tissue from the roots was sufficient to make the plants wilt.

in the soil. *Limonius* spp., principally the sugar-beet wireworm (*L. californicus* Mann.), were found along the coastal areas of California.

The most severe wireworm damage in central California occurred at the Santa Rita nursery near Salinas. Counts were taken in blocks 26 and 29 on August 11–12, 1942, and again on August 21–25, 1943. In block 26 an average of 27 plants per bed were attacked by wireworms in 1942, compared with 12 in 1943; in block 29, 48 plants per bed were affected in 1942 and 13 in 1943. This decline in damage indicated a possibility that wireworm populations in guayule plantings would diminish gradually from year to year rather than increase, as they do in some crops. The damage in 1943 amounted to only a small fraction of 1 percent, and no control measures were required.

Experiments in greenhouse flats showed that small guayule plants could tolerate up to 5 ml. of beta-beta-dichloroethyl ether per gallon of water without injury to the root, and that this concentration would kill about 80 percent of the wireworms. Transplants, on the other hand, tolerated as much as 15 ml. of beta-beta-dichloroethyl ether per gallon without injury.

Counts made in the west section of a nursery near San Clemente, Calif., in April 1943 showed that 14 percent of the plants had been killed or injured by wireworms. Injured plants that did not die were unsuitable for transplanting. This west section had been seeded in December 1942, the shrubs dug for transplanting the following May, and the section reseeded in June 1943. Beginning soon after the seeds had germinated, 48 systematically arranged areas 2 by 4 feet were studied at approximately 2-week intervals for the rest of the season. Less than 0.5 percent of the plants from the June 1943 seeding were injured by wireworms, whereas 14 percent were injured from the December 1942 seeding. In July, 12 representative one-half-cubic-foot samples, taken from the top 6 inches of soil, were screened, and no wireworms were found. The absence of damaged plants and of wireworms near the soil surface indicated that the worms had burrowed deeper into the soil to avoid the heat.

Although it was shown experimentally that established methods of controlling wireworms with insecticides can be applied successfully to guayule growing in nurseries, the methods are expensive. From the observations of this one season it appears that wireworm injury to guayule nursery stock can be reduced below the damaging point by planting wireworm-infested nurseries late in the spring or early in the summer where weather conditions are similar to those of southern California.

## Stem Borer

The larvae of *Agromyza virens* Loew were found to bore down the pith of the main shoots of small guayule plants grown in nurseries (fig. 4) near Salinas by W. A. Campbell and reported by Lange (*3*).

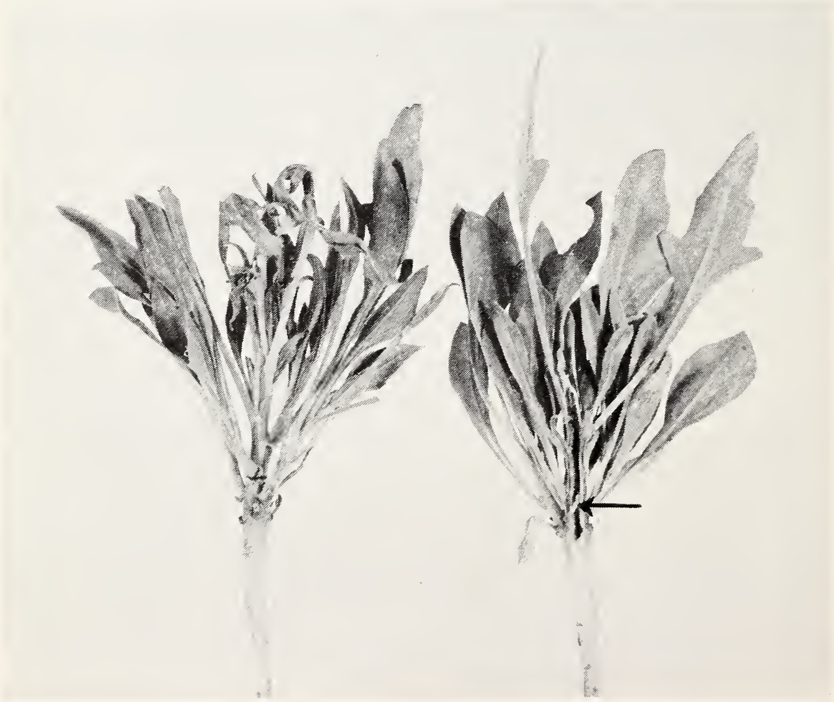

*Figure* 4.—Wilted and rosetted guayule nursery stock in Salinas Valley, Calif., caused by larvae of *Agromyza virens.* Dark bored pith of main shoot with a larva at point indicated by arrow (right). (Photograph by W. A. Campbell.)

The type and degree of damage by *Agromyza* larvae to small guayule apparently vary with the size of the plant. Nursery stock seeded in April and May sustained light damage until September or October, when injury was severe. Most of the bored plants, however, could not be detected without cutting into the pith of the main shoots. Nursery stock seeded in July was small in September and October. These plants showed wilting and dying of their main shoots, which gave some plants a rosetted appearance. Lange (*3*) characterized damage by *Agromyza* larvae as creating rosetted plants. Such a designation apparently applies to the damage to plants that are attacked when small, not to the injury sustained by most of the plants later in the season. Nursery stock at the San Mateo nursery in southern California was severely attacked by larvae of *Agromyza* in June 1943, when about 36 percent of the plants were bored. Terminal shoots did not wilt, and no rosetted plants were noted. This severe attack occurred after the plants had grown large enough to be ready for transplanting, the conditions being similar to those at Salinas in the fall.

On February 18, 1943, plants of equal size were selected from the Quail Creek nursery near Salinas—350 plants that had been bored by the larvae of this fly, to be compared with 350 healthy plants. They were stored at 30° F. until April 3, and then planted in 7 alternate rows of 50 plants each. By July 1, an average of 77 percent of the healthy plants were growing, compared with 64 percent of the bored plants. By analysis the difference was significant at the 5-percent level. When the plants were measured for height and width in October, there was no significant difference in size or shape between the bored and healthy plants. On November 18, 1944, when counts were again made, an average of 86 percent of the healthy plants had survived, compared with 76 percent of the bored plants. All seven replicates showed a higher survival for the healthy than for the bored plants. Even though plants bored by larvae of *Agromyza virens* had a lower survival when planted in the field, it was considered impractical to cull the bored plants, as they were difficult to detect and most of them would grow.

Lange (*3*) reported *Syntomopus americanus* Ashm. and *Halticoptera aenea* (Walk.) as parasites of *Agromyza virens*. In October 1943 the first species was reared from pupae of the flies taken from a nursery near Salinas. These parasites and possibly other factors seem to affect the abundance of the insect, for apparently their numbers had not increased from year to year. No control measures were tried against this insect.

## ANTS

Two guayule nurseries near Indio, Calif., contained colonies of *Pogonomyrmex* spp. during 1943. These ants gleaned seed and removed cotyledon-stage plants from areas ranging from 6 to 10 feet in diameter. The colonies were exterminated by applications of either one-fourth to one-half pound of methyl bromide or 1 pint of carbon bisulfide to each entrance hole. After the fumigant was introduced, dirt was packed tight over the entrance holes to help retain the gases.

*Caution.*—Methyl bromide and carbon bisulfide are poisonous gases. Do not inhale their fumes. As methyl bromide boils at 40° F., it is particularly dangerous at high temperatures. Use an approved gas mask when exposed to these gases at fumigation concentrations. Carbon bisulfide is inflammable and explosive when mixed with air in certain proportions. Handle the liquid with great care and never expose it near fire in any form. Persons not familiar with handling these fumigants are cautioned against using them until they have thoroughly familiarized themselves with the necessary precautions.

### Plant Bugs

*Lygus hesperus* Knight and *L. elisus* Van D. fed on the seed produced by nursery plants. *L. sallei* Stål fed on the growing tips and caused noticeable stunting of nursery stock near San Clemente during 1943.

## FIELD INSECTS

Guayule is grown for 4 to 6 years under field conditions. Figure 5 shows part of a field near Salinas at the beginning of its second growing season. A number of problems calling for insect-control measures developed in this field.

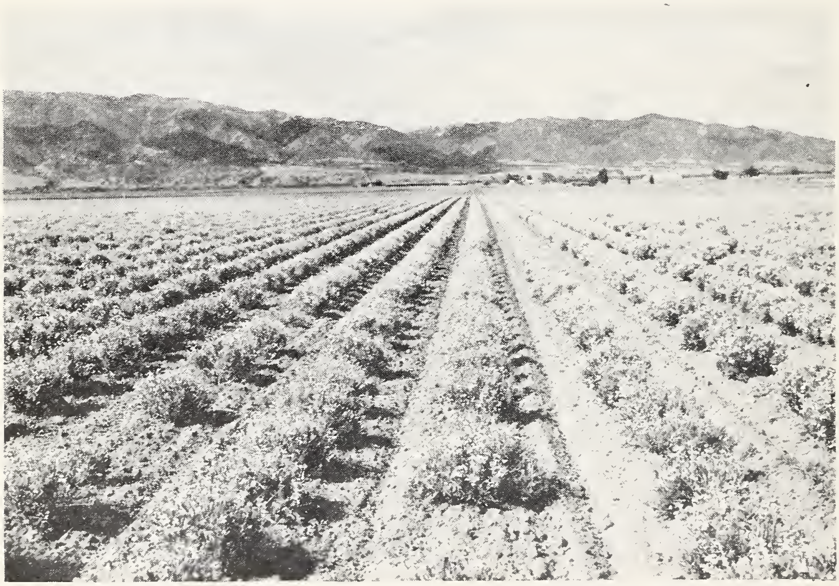

*Figure 5.*—Field of guayule plants growing a second season. (Photograph by W. A. Campbell.)

### Grasshoppers

Grasshoppers were the most destructive insects to plantation guayule grown for rubber production in the Sacramento, San Joaquin, and Salinas Valleys of California. Several species were involved, including *Melanoplus mexicanus devastator* Scudd., *M. cinereus cyanipes* Scudd., *M. differentialis* (Thomas), *M. marginatus* (Scudd.), *M. femur-rubrum* (Deg.), and *Oedaleonotus enigma* (Scudd.). In 1943 large populations of *M. mexicanus devastator* and *O. enigma* bred in range land and migrated to contiguous guayule plantings. Most of the other species bred in alfalfa fields, alfalfa pasture lands, road right-of-ways, and ditch banks, and moved to nearby guayule. *M. mexicanus mexicanus* (Sauss.) and several other species caused noticeable damage to experimental plantings in Arizona in 1944.

Several localized infestations developed in 1944 from eggs deposited in the guayule fields. Late in the season grasshoppers were observed ovipositing over large areas in guayule fields in the San Joaquin Valley. In November an average of half an egg mass per linear foot of row was found in a guayule field near Salinas. The observations made during the 1943 and 1944 seasons indicated that, if guayule is grown for 4 to 6 years before it is harvested, the infested fields may become important breeding grounds for grasshoppers.

Large acreages of guayule were transplanted for rubber production in fields within the San Joaquin, Sacramento, and Salinas Valleys during the winter and spring of 1943. The plants began to sprout and grow in the early spring, and by the middle of May it was necessary to start large-scale control operations in the Sacramento and San Joaquin Valleys to protect guayule from grasshopper attack. Approximately 2,600 acres were baited one to four times. Infestations in the Salinas Valley were localized and did not require large-scale control. The same general areas were again infested in 1944 and were baited one to four times. In addition, two experimental plantings in the Salt River Valley of Arizona required control in 1944. During both seasons standard bait formulas were used, and applications were made with two-wheel spreaders driven by hand. In 1944 a power-driven spreader was used successfully. All control programs were effective. In 1943 only 7 acres were injured seriously enough to call for replanting. In 1944 some plants were killed along the edges of several fields, but the area affected amounted to only a few acres. In 1945 it was found that a flash irrigation was necessary before baiting in order to kill grasshoppers successfully within guayule fields.

The extent of damage inflicted on guayule by grasshoppers and the type of feeding depend largely on the age of the plant. In transplanted guayule that is just beginning to sprout and grow, grasshoppers generally start feeding at the base of the plant and, continuing upward, remove the cortex from the main stems. At this stage of growth little feeding on the main stem is required to kill the plant. When the plants have become established and are in full leaf and in the flowering stage, the grasshoppers start feeding on the flowers and feed downward. In heavy infestations the plants are defoliated and the cortex of branches is removed, so that the plants die. Different degrees of guayule defoliation by grasshoppers are shown in figure 6. Plants almost completely defoliated (fig. 6, *C*) usually survive under favorable growing conditions, but plants completely defoliated (fig. 6, *D*) usually die. Guayule growing in the field for the first season appears to be more susceptible to fatal grasshopper injury than do second-season and older plants. Apparently grasshoppers

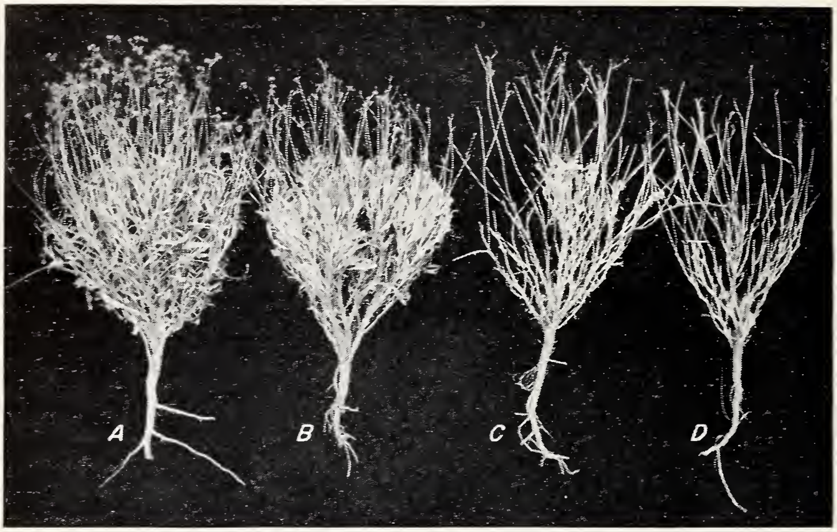

*Figure 6*.—Degrees of guayule defoliation by grasshoppers: *A*, Noninjured plant; *B*, plant with flowers removed; *C*, plant almost completely defoliated; *D*, plant completely defoliated.

are unable to girdle the main branches after the bark becomes tougher and thicker with age.

## TERMITES

The exposed portions of guayule nursery stock transplanted in fields in southern Texas were encased in mud tubes by a tube-forming termite, *Amitermes tubiformans* (Buck.). The termites fed on the cortex tissues of the semidormant plants, killing some and injuring others. They seldom killed guayule when growth had begun after transplanting, although larger plants often became partially encased after wet weather. Barring interference by rain, control was effected by destroying the mud tubes and dusting the plants with paris green at the rate of 15 pounds per acre soon after transplanting. Termite damage was also greatly reduced by dipping the nursery stock in a suspension of DDT, paris green, or calcium arsenate just before transplanting.

*Caution*.—DDT, paris green, and calcium arsenate are poisonous. Do not allow children or animals to have access to them.

## LEAFHOPPERS

Adults and nymphs of a green leafhopper, *Empoasca arida* DeL., were second in abundance on guayule in California fields. They caused no noticeable injury and required no control measures. In experiments, however, pyrethrum-oil sprays, as well as DDT dusts and emulsions, were very effective against them. Many other leafhoppers frequented the plants, but their numbers were low during the seasons reported.

## APHIDS

The spotty infestations of aphids found in guayule plantations mainly involved the species reported infesting nurseries. Parasites and predators, however, subdued them before they became so numerous as to require control measures.

## LACE BUGS

A lace bug, *Corythucha morrilli* (O. and D.), reproduces on guayule in southern Texas and New Mexico during the early summer. When lace bug numbers are large, they lower the vitality of the plants and reduce the rate of growth. In June 1944 growth was retarded in a 12-acre plot at Linn and in a 16-acre plot at Rio Grande City, Tex., where there had been two generations by late June. Preliminary tests indicated that DDT controls this insect.

Guayule plots near Yuma and Gila Bend, Ariz., were infested with *Corythucha* sp. during the early summer of 1943. With hot weather the insects disappeared, as they did in Texas.

## PLANT BUGS

Plant bugs were numerous in California guayule fields and nurseries during the flowering season, April to October. The predominant species was *Lygus hesperus*, with some *L. elisus* and *L. apicalis* Fieber. *L. apicalis* occurred only along the coastal areas. According to Romney and coworkers (*7*), these insects reduced the weight and viability of guayule seeds. In the absence of seeds the insects were forced to feed on young shoots, stunting their growth. DDT dusts and sprays effectively controlled the plant bugs.

*Lygus sallei* feeds almost entirely on the growing tips of plantation guayule in the early spring, thereby stunting the growth so that several months are required for recovery. In April, May, and June 1943, this insect damaged areas near Salinas, ranging from several acres in which most plants were affected to a field in which only occasional plants were stunted. Control was effected by dusting sulfur at the rate of about 50 pounds per acre with rotary hand dusters. Damage was very light in the spring of 1944. Details of damage by this species are given by Romney and coworkers (*7*).

*Chlamydatus associatus* (Uhler) reproduced on plantation guayule in the San Joaquin Valley. The insect became abundant, but no noticeable damage was attributed to it.

The mirid *Sixeonotus areolatus* Knight is one of the most important potential pests of guayule in southern Texas. This insect reproduced on guayule growing there for the first season in 1943 under field conditions. Noticeable damage was evident in a plot at Lyford in 1944, after several generations of insects had developed. A 2-percent nicotine dust in sulfur, applied at the rate of about 25 pounds per acre, gave satisfactory control in the lower Rio Grande Valley. Sulfur alone failed to check this insect in any plot.

**Caution.—Nicotine and its compounds are violent poisons; exercise care in their use.**

## CARROT BEETLE

Adults of the carrot beetle (*Ligyrus gibbosus* (Deg.)) attacked the roots of the guayule in California, Arizona, and Texas. The adults burrowed into the soil around the base of guayule plants, as apparent from holes near the dead plant (fig. 7, *A*). The beetles fed on the roots, removing large areas of the cortex tissues, which often killed the plants. Roots from 2-year-old plants at Indio showed damage to cortex tissues on the root (fig. 7, *B*) extending from the crown down 9 inches. Larvae of this insect caused similar damage, but adults that had migrated from an adjacent breeding place did most damage.

Damage was reported in 1942 from many parts of California and Arizona, as well as from Balmorhea, Tex., but did not reoccur in 1943 and 1944. Late in June 1944, however, a heavy migration of the beetles infested plots in the Bell Ranch nursery near Indio, and did most of their damage within about a week. Outside rows on the east side of the plots were most severely damaged, an indication that the migration had come from the east. In one plot some small animal had dug the beetles from around the roots, leaving holes with the roots exposed. Infestations originating with sudden migrations of this insect from adjacent breeding areas may injure small plots in which all plants are important, but over-all damage to large plantation acreages from this insect is not anticipated. Lange (*3*) reported that *Ligyrus californicus* Csy. damaged guayule in 1942 in the Moreno and Palmdale plots in southern California. Apparently this species also attacks the plant, but specimens found later were identified as *L. gibbosus.* Control measures were not attempted.

## WIREWORMS

In the vicinity of Los Banos, Calif., many transplants were killed in a 20-acre portion of a guayule field in 1943 and again in 1944 by larvae of *Melanotus* sp. With the exception of this acreage, however, damage by this species and by *Limonius* spp. in the other fields amounted to less than 1 percent. Wireworms were present in dry-land areas as well as in irrigated lands, although the infested acres were in irrigated land.

## MOTH LARVAE

Near Salinas, larvae of the salt-marsh caterpillar (*Estigmene acrea* (Drury)) injured breeding stock transplanted into the field in the spring of 1943. The moths laid clusters of eggs on individual plants, and upon hatching the larvae defoliated the infested plant before moving on to others. The larvae reduced stands of guayule in the cotyledon stage in the nurseries and in the field. Dusting the plants with straight calcium arsenate effectively controlled these larvae on larger plants, but not on cotyledon-stage plants.

On July 15, 1943, near Shafter, Calif., larvae of the yellow-striped armyworm (*Prodenia ornithogalli* Guen.) crawled from an adjoining alfalfa field into guayule to feed on flowers and tender foliage. Control was effected by dusting with calcium arsenate.

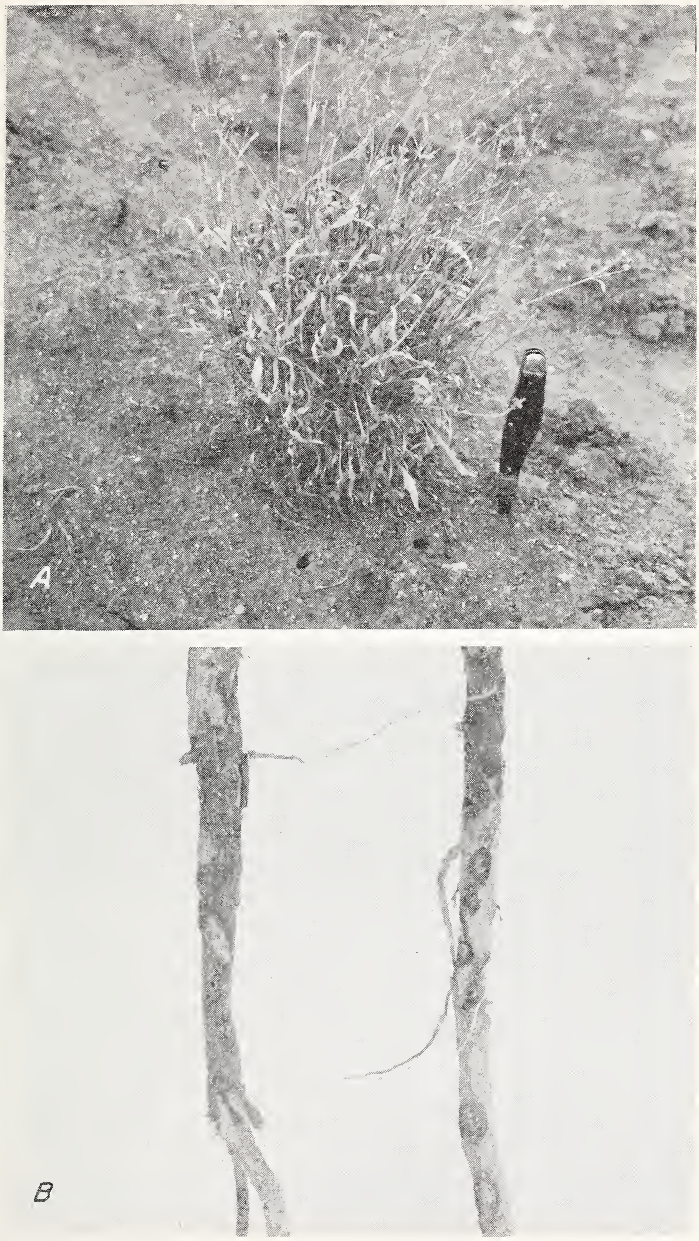

*Figure* 7.—Damage to guayule by adults of the carrot beetle: *A,* Dead plant, showing beetle entrance holes near its base; *B,* root portions beginning 6 inches below injury at crown, showing damage to cortex tissues. (Photograph by W. A. Campbell.)

Late in September 1944 larvae of the garden webworm (*Loxostege similalis* (Guen.)) completely or partially defoliated many guayule plants in a 69-acre field near Raymondville, Tex. In 1943 and 1944 this species destroyed more guayule foliage than did any other insect in Texas and New Mexico.

## ANTS

A fire ant, *Solenopsis xyloni* var. *maniosa* Whlr., was found attacking the roots of plantation guayule (fig. 8) in the San Joaquin and Sacramento Valleys. It fed on the cortex tissues, often killing the plants. Fire ant injury was first detected in July 1943. Since then its importance has been determined and control measures have been developed. These ants killed several thousand guayule plants and weakened as many more during the seasons of 1943 and 1944. Nests were often found at the base of dead guayule plants, but most of them occured at random on top of the bed. Experiments for control of the fire ant were conducted in fields where damage was common. A 1-pound can of methyl bromide, applied with a special applicator, was sufficient to kill the ants in approximately 10 nests.

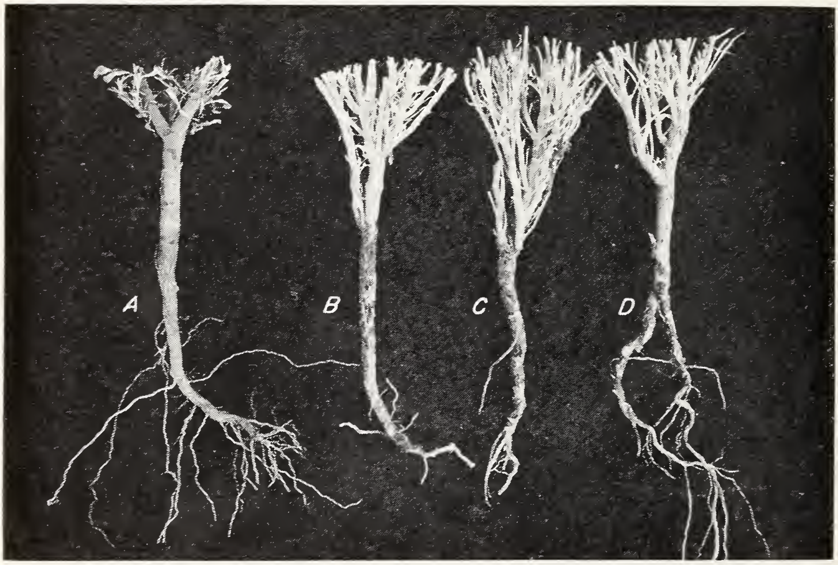

*Figure 8.*—Damage to roots of guayule by a fire ant: *A*, An uninjured root is shown for comparison with *B, C,* and *D,* which died as the result of their injuries.

Nests of the fire ant were easily located several days after an irrigation and before cultivation. Dosages of 40 or 20 ml. of either beta-beta-dichloroethyl ether or D-D mixture (1,2-dichloropropane-1,3-dichloropropylene) were applied. The experiment comprised five treatments replicated eight times. The nests were opened with the point of a shovel and the soil fumigant was poured in, after which the soil was packed over and around the nest. In most instances the results showed that 20 ml. of either fumigant was sufficient to kill inhabitants of an entire nest. The ants in all eight check nests were alive, whereas none were alive in nests treated with 20 ml. of beta-beta-dichloroethyl ether. However, a few ants were alive in one nest treated with 20 ml. of D-D mixture. These materials are much safer for use by laborers than is methyl bromide.

Colonies of the red harvester ant (*Pogonomyrmex barbatus* (F. Smith)) caused some damage to transplanted guayule in test plots and to larger experimental plantings in New Mexico and Texas. The defoliation of plants within several feet of the entrance holes of the colonies created the usual circular barren area about each colony. In seeded plots the ants removed seed and cotyledon-stage plants over areas ranging from 6 to 10 feet in diameter, as they did in the nurseries near Indio. Fairly good control was afforded by pouring a pint of carbon bisulfide down each entrance hole in the early morning, and then packing dirt well over the holes. A dosage of one-fourth to one-half pound of methyl bromide, dispensed with a special applicator, also was effective.

The Texas leaf-cutting ant (*Atta texana* Buckl.) caused some damage to plots near Del Rio, Pearsall, and Derby, Tex. These ants defoliated transplanted guayule in the vicinity of their colonies. Control was effected by application of 2 pounds of methyl bromide to each colony.

***Caution.*—See warning for methyl bromide under Ants, page 8.**

## GREENHOUSE INSECTS

### MITES

Guayule and closely related plants being grown for experimental purposes in greenhouses at Salinas and Capitola, Calif., were attacked by various insects and control measures were required. The two-spotted spider mite (*Tetranychus bimaculatus* Harvey) reproduced and fed mostly on the under surfaces of the leaves. Under greenhouse temperatures, ranging from 70° to 85° F., the life-cycle rate was accelerated, so that many generations developed in a year. Guayule appears to be a very good host of *T. bimaculatus*. When plants are kept for long periods under conditions favorable for reproduction of the mites, effective control measures are essential for successful maintenance of the plants. This pest was not satisfactorily controlled with sulfur and other recommended materials in 1943, but in 1944 and later, it was successfully controlled by applying a 0.3-percent DDT emulsion with a paint gun at an air pressure of 60 or more pounds per square inch, as reported by Romney and coworkers (*8*) and Romney (*6*).

### CRICKETS

A field cricket (*Acheta* sp.) was a menace to seedling guayule plants in greenhouses. The insects destroyed all but the stem below the crown on plants in the cotyledon stage and partially defoliated the larger ones. The fall rains brought large infestations in greenhouses. Control was effected by applying a 5-percent DDT dust lightly on places frequented by the insects, so that they were killed by walking over the treated areas. A bait composed of 1 part by weight of a 10-percent

DDT dust and 10 parts of sweetened bran was effective also. The combined treatment of dusting and baiting was used when there was an urgent need for removing the pests quickly.

## APHIDS

The green peach aphid and the melon aphid were found in greenhouses near Salinas and Capitola. Nicotine fumigation was very effective, as was also the spray schedule with DDT emulsion used for the control of mites.

**Caution.—See warning for nicotine under Plant Bugs, page 11.**

## MEALYBUGS

The Mexican mealybug (*Phenacoccus gossypii* T. and C.) was a pest on guayule in greenhouses at Salinas in 1943. The use of recommended control measures effectively reduced the numbers, but treatment at intervals did not eliminate the mealybugs. In 1944 a 0.3-percent DDT emulsion spray completely eradicated them after two or three treatments.

## WHITEFLIES

The greenhouse whitefly (*Trialeurodes vaporariorum* (Westw.)) and *Aleyrodes spiraeoides* Q. were also troublesome pests of guayule growing in greenhouses in 1943. In 1944, however, these insects proved to be highly susceptible to DDT. A 0.3-percent DDT emulsion spray eliminated them.

## LEAFHOPPERS

*Empoasca arida* reproduced in abundance on guayule grown in greenhouses until 1944, but disappeared after DDT had been used to control spider mites.

## LEAF MINERS

Under greenhouse conditions at Salinas larvae of *Phytomyza atricornis* Meig. mined guayule leaves (fig. 9). The larvae were injurious to very small plants, several basal leaves being killed by the feeding of a single larva. Leaves on larger plants (fig. 9) usually were not killed, but were heavily mined. Periodic spraying with a 0.3-percent DDT emulsion reduced damage by killing the adult flies and by keeping the plants immune for a time.

## MOTH LARVAE

Larvae of the orange tortrix (*Argyrotaenia citrana* (Fern.)) fed on the growing tips and leaves of guayule in greenhouses and outside in pots at Salinas. The larvae curled leaves together loosely with webs and fed within them. Damage was not serious from the standpoint of plant survival, but the larvae interfered with experimental work. Calcium arsenate used as a dust was effective against this insect.

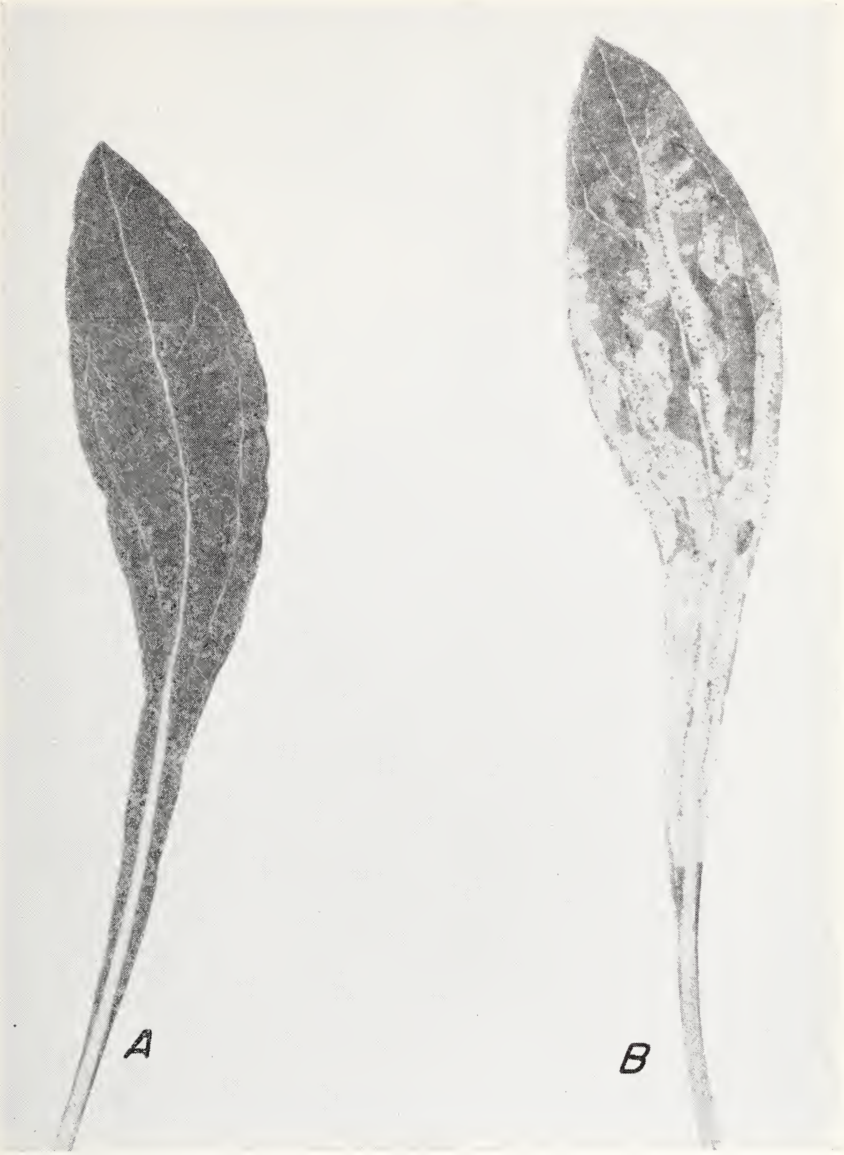

*Figure 9.*—Guayule leaves: *A,* Normal leaf; *B,* leaf mined by larva of *Phytomyza atricornis.*

## SUMMARY

Guayule (*Parthenium argentatum* A. Gray) is a shrub cultivated during World War II as a source of rubber by the Emergency Rubber Project under management of the Forest Service. By 1944 about 31,000 acres of guayule were being grown, mostly under irrigation, in the central and coastal valleys of California. The crop requires 4 to 6 years' growth before it is ready for harvest.

Guayule plants growing under nursery conditions in California from 1943 to 1945 were injured by a number of insects. *Ulus crassus* (Lec.), *Diabrotica undecimpunctata* Mann., and *Pogonomyrmex* spp. reduced the stand of cotyledon-stage guayule when they were sufficiently abundant. Thrips, principally *Frankliniella* spp., the onion thrips (*Thrips tabaci* Lind.), and *Chirothrips aculeatus* Bagn., caused the leaves of small plants to curl and become distorted, but they did little damage. Wireworms (*Limonius* spp.) killed as many as 14 percent of small nursery plants. Larvae of a stem borer, *Agromyza virens* Loew, bored down through the pith of the main shoots of nursery plants, but killed only a small percentage of them.

Guayule grown under field conditions in California, Texas, New Mexico, and Arizona was also injured by a number of insects during the same 3-year period. Grasshoppers, principally *Melanoplus* spp. and *Oedaleonotus enigma* (Scudd.), were the most destructive insects to plantation guayule. They bred within California fields, but also migrated into them from breeding areas, killing and damaging plants by removing the cortex from the branches. A tube-forming termite, *Amitermes tubiformans* (Buck.), encased newly transplanted plants and removed cortex from them in southern Texas. *Empoasca arida* DeL. was the second most abundant insect on plantation guayule in California, but little damage, if any, was attributed to it. *Corythucha* spp. reproduced on guayule so abundantly in Texas, New Mexico, and Arizona that the plants were damaged. *Sixeonotus areolatus* Knight also damaged guayule in southern Texas.

Plant bugs, *Lygus* spp., were very abundant during the flowering period (April to October) in California fields. *Lygus hesperus* Knight reduced the viability of guayule seed and stunted plant growth, so that the bugs were forced to feed on the terminal shoots. *Lygus sallei* Stål. stunted the terminals. Adults of the carrot beetle (*Ligyrus gibbosus* (Deg.)) killed guayule plants in California, Arizona, and Texas in 1942, but did not reappear until 1944 at Indio, Calif.

Wireworms, *Limonius* spp. and *Melanotus* sp., did little damage to plantation guayule, except in a 20-acre field in California when the latter species greatly reduced the stand. Larvae of the salt-marsh caterpillar (*Estigmene acrea* (Drury)) and the yellow-striped armyworm (*Prodenia ornithogalli* Guen.) periodically defoliated guayule in California. Larvae of the garden webworm (*Loxostege similalis* (Guen.)) seriously defoliated guayule in Texas and New Mexico in 1943 and 1944. A fire ant, *Solenopsis xyloni* var. *maniosa* Whlr., weakened and killed thousands of plants in California by feeding on the root cortex. Colonies of the red harvester ant (*Pogonomyrmex barbatus* (F. Smith)) defoliated guayule plants and removed seed and cotyledon-stage plants in southern Texas within areas 6 to 10 feet in diameter. The Texas leaf-cutting ant (*Atta texana* Buckl.) also defoliated plantation guayule in Texas.

When grown under greenhouse conditions, guayule was subject to infestation by the following insects: The two-spotted spider mite (*Tetranychus bimaculatus* Harvey), which reproduced abundantly on guayule; a field cricket, *Acheta* sp.; the green peach aphid (*Myzus persicae* (Sulz.)); the melon aphid (*Aphis gossypii* Glov.); the Mexican mealybug (*Phenacoccus gossypii* T. and C.); the greenhouse whitefly (*Trialeurodes vaporariorum* (Westw.)) and *Aleyrodes spiraeoides* Q.; a leaf miner, *Phytomyza atricornis* Meig.; and larvae of the orange tortrix (*Argyrotaenia citrana* (Fern.)).

Conventional control measures were used against insects injurious to guayule grown under nursery, field, and greenhouse conditions. After 1944 the use of DDT simplified control of many forms injurious to guayule.

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